

Pakistan Wetlands GIS - a multi-scale national wetlands inventory

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Abstract – Pakistan possesses a great variety of wetlands distributed throughout the country whose number exceeds over 200 identified wetlands or wetland complexes. The information about these resources is patchy and has not been compiled and updated systematically except documentation of only 48 wetlands in the Asian Directory of Wetlands in 1989. In order to fill the information gap, GIS-based Pakistan Wetlands Inventory (PWGIS) is developed under Pakistan Wetlands Programme (PWP). The spatial framework of PWGIS follows Asian Wetlands Inventory guidelines. FAO's Land Cover Classification System (LCCS) is adopted to harmonize the legend at all the scales. A Spatial Data Infrastructure (SDI) is developed at National Council for Conservation of Wildlife (NCCW) that has deployed PWGIS to use, maintain, improve and distribute it among other conservation organizations.

Keywords: Pakistan, Wetlands, Inventory, LCCS, SDI

1. INTRODUCTION

Pakistan possesses a great variety of wetlands distributed almost throughout the country, from the coastal mangroves and mudflats on the Indus delta to the glacial lakes of the Himalayas (Scott, 1989). The importance of these wetlands was first brought to the notice of the international community at a technical meeting on wetland conservation held in Ankara, Turkey, in October 1967 (Savage, 1968). In 1976 Pakistan became a Contracting Party to the convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention, 1971). By 2002, 19 wetlands of Pakistan have been internationally recognized by Ramsar Convention Bureau as of global importance. These wetlands comprise of unique habitat, species and genomes. Almost 130 million people are permanently and 3-4 million people displaced from other countries are dependant on these wetlands (Garstang et al., 2003).

Knowing the location, distribution and character of wetlands, their values and uses, and the threats to them is an essential basis for developing and implementing management for their wise use. However, the global review of wetland inventories indicated lack of a standardised, systematic approach to wetland inventory across the Asian region. The review also suggests that national level wetland inventories should be developed by using an approach that is comparable with other wetland inventories and for which the Ramsar Convention should provide guidance (Finlayson & Spiers, 1999).

The information about the wetlands resources of Pakistan is patchy and has not been compiled and updated systematically except the documentation of only 48 significant wetlands,

categorized in 11 wetlands types, in the Asian Directory of Wetlands in 1989 (Scott, 1989).

In order to fill the information gap, GIS-based Pakistan Wetlands Inventory (PWGIS) is developed under Pakistan Wetlands Programme (PWP). PWP aims to promote the sustainable conservation of freshwater and marine wetlands and their associated globally important biodiversity in Pakistan by implementing sustainable wetland conservation measures at four large demonstration sites that represent four broad wetland ecological zones of Pakistan. The inventory will serve multiple scientific, academic and awareness purposes.

2. METHODS

Asian Wetlands Inventory guidelines (Finlayson et al., 2002) were followed to develop multi-scale database at three levels:

- 1: 250,000 scale mapping for 174 significant wetlands
- 1:50,000 scale mapping for four PWP demonstration sites and 46 Protected Wetlands designated either under Ramsar Site, National Park, Wildlife Sanctuary, or Game Reserve, and
- 1:10,000 scale mapping for selected highly significant wetlands

Respectively, ASTER (15 m), SPOT (2.5 m) and Quickbird (0.6 m) satellite images were used. Object Based Image Analysis (OBIA) method was adopted for satellite image based Land Cover mapping. In addition to spectral values OBIA also considers shape, texture and context information of the image objects for pattern recognition (Benz et al., 2004). FAO's Land Cover Classification System (LCCS) was adopted to harmonize the legend at all the scales (Gregorio et al., 2005).

To quantify the wetlands area of Pakistan, Crist (1985) derivation of the visible, near-infrared, and middle-infrared coefficient for wetness, MODIS-16 Terra imagery was used to calculate wetness index to delineate lowland wetlands:

$$\text{Tasseled Cap Wetness Index (W)} = 0.315_{\text{MOD3}} + 0.2021_{\text{MOD4}} + 0.3102_{\text{MOD1}} + 0.1594_{\text{MOD2}} - 0.6806_{\text{MOD6}} - 0.6109_{\text{MOD7}}$$

Upland wetlands were delineated using 90m SRTM Digital Elevation Model upstream and slope threshold on <1 percent (Kulawardhana et al., 2008).

The terminology used to reference "watersheds" is not standardized and often creates a miscommunication when people do not share the same sense of scale for a given watershed term (McCammon, 1994). A clear description of the extent of watershed boundaries, in the form of national level database, is important to avoid such misunderstanding. The automated extraction of topographic parameters from DEM is recognised as a viable alternative to traditional surveys and manual evaluation of

topographic maps, particularly as the quality and coverage of DEM data increases. Multi-scale watershed database of Pakistan (Qamer et al., 2008) was derived from elevation data of the Shuttle Radar Topography Mission (SRTM) at 90 meter resolution and elevation derived from ASTER satellite image of 30 meter spatial resolution through a sequence of procedure including preparation of depressions less DEM, calculation of flow accumulation, stream links, and identification of watershed boundaries. In addition, fine detail drainage network was delineated by calculating stream order on flow accumulation value and applying stream to feature algorithm.

The Wetlands Survey Programme Section (WSPS) of Pakistan Wetlands Programme is responsible to carryout nation-wide wetlands' surveys on birds, mammals, fish, micro & macro invertebrates, reptiles and amphibians, vegetation, and water quality. GIS provides base maps for field navigation and data compilation. Standardised data encoding forms with GPS readings are being used to collect data which are compatible with database built on PWI data model. All these biodiversity data along with their observers' details and observation conditions are being maintained in a web-accessible database deployed at National Council for Conservation of Wildlife (NCCW), Islamabad.

Pakistan Wetlands Inventory (PWI) data model (Qamer, 2007) integrates Wetlands Survey Programme and Wetlands GIS together. The model is based on three major components given below and their relationship is shown in Figure 1.

- Asian Wetlands Inventory guidelines
- Observational Data Standards by Taxonomic Database Working Group-GBIF
- Geographic Information-Metadata ISO 19115

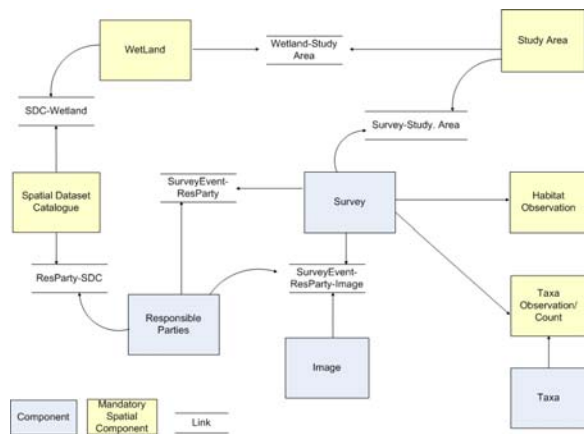


Figure 1. Main components of the PWI data model

Web-GIS application of the inventory has been developed, as part of Spatial Data Infrastructure of NCCW GIS Laboratory, for data entry and interactive visualization. Open source software tools including Postgres/PostGIS, UMN Mapserver and PHP scripts were used for building this application.

An unclear boundary is one of the major constraints in managing the Protected Areas. Most of the notifications on Protected Areas of Pakistan do not completely explain their boundary extent. The boundaries of all the protected wetlands were mapped into GIS format using government record, field data and GIS maps.

Capacity-building of government and non government conservation organisations in using GIS in their decision making is one of the key pillars in the successful deployment of Pakistan Wetlands GIS. Comprehensive courses have been structured to train the participants in using GIS, GPS and Remote Sensing, with specific perspective to conserve wildlife and their habitats, through formal lectures, hands-on sessions and field exercise. So far 75 participants representing all the provinces and territories, working in the field of conservation and natural resource management has been trained under this initiative.

3. RESULTS AND DISCUSSION

Garstang et al., (2003) categorized Wetlands of Pakistan into four broader ecological categories i.e., Montane and Alpine region, Semi-arid region, Arid region and coastal region (Figure 2).

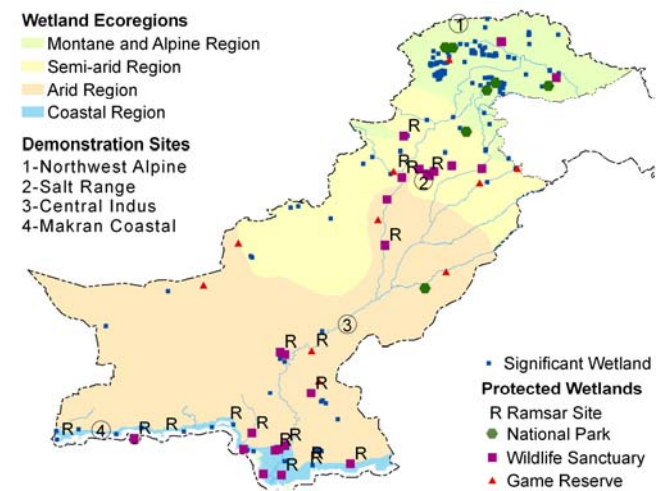


Figure 2. Distribution of Significant Wetlands and Wetlands Ecoregions of Pakistan

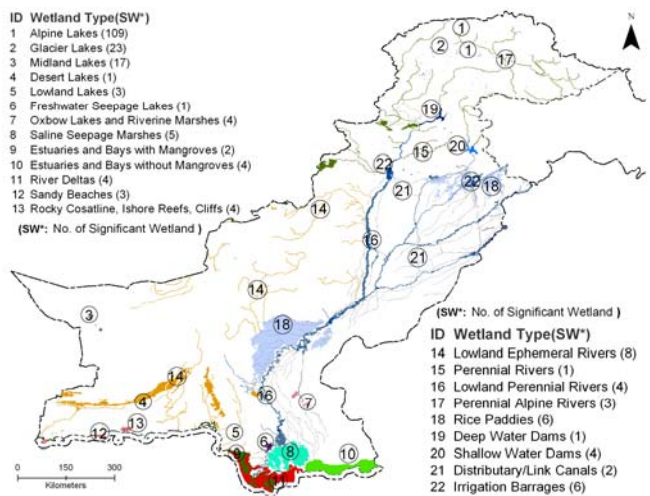


Figure 3. Wetlands Types of Pakistan

Based on the Wetness index of MODIS – 16 days composite image of August 2008 an area of 6,734,000 ha was identified as Wetlands which is 8.5% of terrestrial area of Pakistan. Based on the hydrologic, geomorphologic, chemical, or biological factors 22

distinct types of wetlands were classified and representative areas were delineated (Figure 3 & Figure 4).

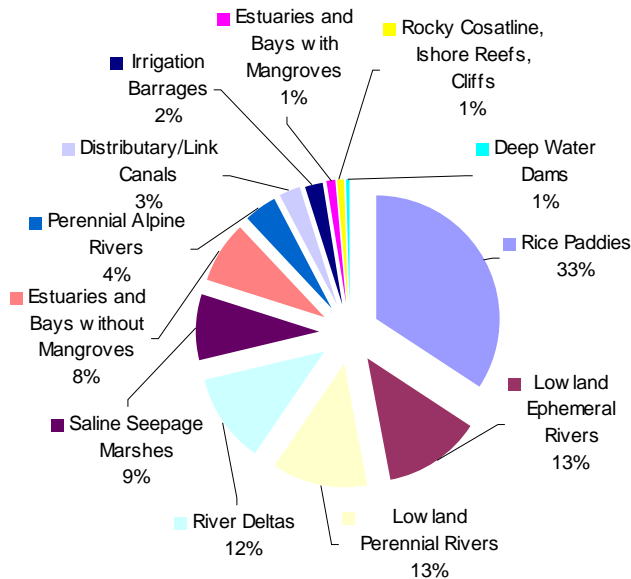


Figure 4. Distribution of Wetlands Types of Pakistan

In total, 220 Wetlands are categorised as Significant Wetlands by the programme which include 46 Protected Wetlands (1,479,794 ha); further designated as, 7 National Parks (128,563 ha), 25 Wildlife Sanctuaries (1,213,784 ha), 10 Game Reserves (137,447 ha); which also include 15 Ramsar Sites. There are 4 Ramsar Sites (60,646 ha) which do not have any other protected status. The total 19 Ramsar sites cover an area of 1,343,550 ha (Figure 2).

A standardised watershed database of Pakistan has been developed for in-situ watershed management and can also be aggregated with global and regional databases (e.g., WWF-HydroSheds, Watersheds of the world). Based on the hydrological analysis of 90 m SRTM DEM watershed boundaries and drainage network were delineated (Table A).

Table A. Basins and sub-basins of Pakistan

Basin	Sub Basin	Watershed	Area (Km ²)
Indus	35	171	1,174,562
Dasht	8	37	116,191
Hamun-i-Mashkhel	3	-	188,436

Sub-watershed boundaries of 46 Protected Wetlands were delineated using 30 m ASTER satellite image based DEM.

Land cover mapping of these wetlands was also conducted on sub-watershed extent. An example of such study is given in Figure 5 and a list of all the vegetation types of Wetlands of Pakistan are given in Table B. In one of the significant land cover studies of high altitude areas, 13 patches of Alpine Peatlands covering an area of 2,000 ha were identified, in the Broghil Valley, Upper Yarkhun, District Chiral, NWFP. Similarly Alpine Peatlands were also observed in the areas of Langar-Shandur Wetlands during the field surveys.

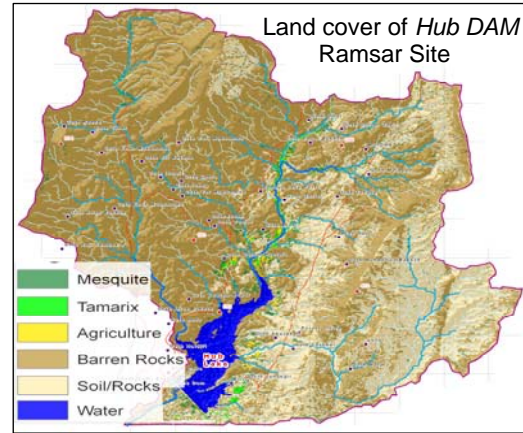


Figure 5. Land Cover map of Hub Lake on sub-watershed extent

In the coastal regions, 67,000 ha mangroves cover mapped in five distinct sites (Table C).

Table B. LCCS definition of vegetation types of Wetlands of Pakistan

LCCLLevel	LCCOwnLabel	LCCLLabel
A3A12B2C1 D1E1-C5	Mangroves	Broadleaved Evergreen Trees on Permanently Flooded Land
A6A16B4C1E5	<i>Saccharum</i> spp., Narkial & Phragmites	Mixed Sparse Grassland on Permanently Flooded Land .
A4A12B3C2	<i>Typha</i> spp.	Closed Shrubs On Temporarily Flooded Land.
A3A10B2XXD1 E1-B7	<i>Tamarix</i> spp.	Broadleaved Evergreen Low Trees
A3A10B2XXD1 E1-B6E4- O1O10	Mesquite	Semi-Evergreen Medium High Trees
A4A11B3XX D1E1	<i>Dodonaea</i> <i>Viscosa</i>	Broadleaved Evergreen Shrubland
A3A11B2XXD1 E1-B7	<i>Acacia modesta</i>	Broadleaved Evergreen Woodland
A3A11B2XXD1 E1-B5E4	<i>Acacia nilotica</i>	Semi-Evergreen Woodland
A24	Submerged Vegetation	Natural & Semi-Natural Aquatic or Regularly Flooded Vegetation
A5A12B4- A9B13	Lotus	Closed Short Free Floating Forbs.
3A10B2XXD1E 2	Shishum	Broadleaved Deciduous Trees
A6A20B4	Grasses	Closed to Open Grassland
A4A11-A12	Shurbs Mix	Open ((70-60) - 40%) Shrubs (Shrubland)
10001-W7 A1-W7	Peatlands	Closed short Grassland on Permanently Flooded land
A4A11B3XXD2 E1-B10	Juniper	Needleleaved Evergreen Dwarf Shrubland
A1-A7A10-W8	Orchards Trees	Broadleaved Deciduous Tree Crop(s)
A3A10B2XXD2 E1-B5	Conifer	Needleleaved Evergreen High Trees
A3A10B2XXD1	Broadleaved Trees	Broadleaved Closed Trees

A1-W7	Plantation	Tree Crop(s)
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Table C. Mangroves Site of Pakistan

Site Name	Area (ha)	Satellite Image Year
Indus Delta	62,000	2000
Sandspit	370	2003
Miani Hor	3,780	2001
Kalimat Khor	500	2004
Jiwani	350	2006

Pakistan is rich in avifauna diversity having a total of 668 resident and migratory bird species belonging to 85 families and 23 orders. A higher percentage of Pakistan's bird fauna is migratory with a huge invasion of palaeartic winter visitors that is over 30% of recorded species (Roberts, 1991 & 1992). Study was carried out to assess the diversity and richness of bird species in the four Demonstration Sites of Pakistan by using GIS. Central Indus Wetlands Complex and Salt Range Wetlands Complex are found most diverse with reference to migratory and resident birds and are the most ecologically significant areas among all the wetland complexes.

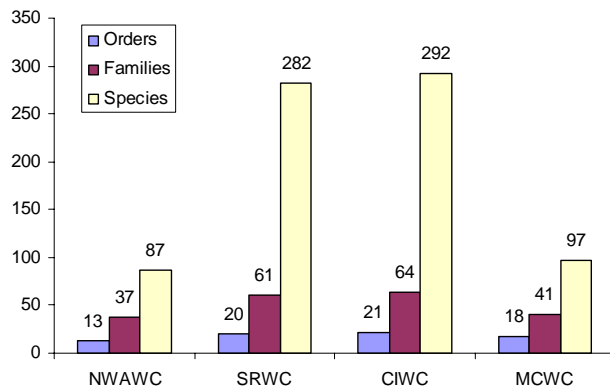


Figure 6. Bird species diversity at wetland demonstration sites

Current study is first comprehensive attempt to analyse the extent and characterization of the wetlands of Pakistan. Thoroughly documented standards and techniques applied for the development of this inventory can also be effectively used for repeated monitoring of these wetlands. This national level study also provides the basis for developing other key national inventories including forest and wildlife.

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